Deriving Quantum Field Theory and General Relativity from Classical Logic: Addressing Hilbert's Sixth Problem

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Abstract

While modern physics aligns numerically with observation, according to Smullyan's definition of formal systems, the absence of a single underlying logical framework prevents the derivation of non-mathematical conclusions that remain consistent under unification. As a result, current theories adopt mutually incompatible ontological structures: some treat spacetime as being dynamic while others treat it as fixed; some require strictly local interactions while others admit non-local correlations; and some depend fundamentally on quantization whereas others rely on smoothness and continuity. It follows that fundamental concepts such as space, time, and locality cannot be coherently defined within one theory without being negated by another. This framework addresses these inconsistencies by establishing methods in which these foundational concepts are derived directly from logic (this avoids complications with Bell's theorem in ways we didn't previously understand), enabling unification through internal consistency. The Lagrangians for the gravitational, scalar, fermion, and gauge fields are formulated such that space, time, and quantization are treated uniformly. By axiomatizing physics, this framework unites mathematics, ontology, physics, and aspects of philosophy under a single logical system (eq. 73), providing a detailed framework for understanding the universe.

1 Introduction

Assume that the equation $x = y \cdot z$ accurately models some observation over n scientific experimental tests. **(a)** Even in the context where $n \to \infty$, this would not permit you to determine the ontological meaning of x, y, and z. That is, **(b)** equations establish relationships between variables, but they don't let you derive the meaning of the variables themselves. If you are instead given the equation in $d = v \cdot t$ form, you have some preconceived ideas about what distance, velocity, and time are that at least make you believe that you understand this second form of the equation more than the first. However, nothing establishes that any initial assumptions about what these variables mean correctly correspond to their physical meaning in reality. Thus, physics is functional but not necessarily ontologically reliable. **(c)** While it seems reasonable that a mathematical dimension must correspond to a physical dimension, nothing establishes this as a fundamental truth. This distinction determines the difference between the universe being represented as the entire spacetime manifold [1], or it just being a spatial slice of the manifold that evolves [2], so the ontological meaning of what space and time are can't just be assumed.

With that said, it is our concept of space and time that determines the ontological structure (e.g., block vs slice) of our universe that the equations describe. We can extend this idea to include concepts of space and time, represented as X and ζ respectively, not previously conceived of. It should be clarified that this process preserves numerical predictions as exemplified by $d = v(t) \cdot t = v(\zeta) \cdot \zeta$. By changing the meaning of space and time, the structure of spacetime is changed to the structure referred to as U in which general relativity (GR) and quantum field theory (QFT) share a common mechanism (one ontological M field that causes everything). To elaborate, let the equations of GR and QFT be represented as $GR(t, x)$ and $QFT(t, x)$ respectively. These equations are numerically precise, but they treat space, time, and quantization non-uniformly [3–5], justifying the need to change from spacetime to U. We therefore assume $GR(\zeta, X)$ and $QFT(\zeta, X)$ and establish a biconditional (eq. 8) from which to derive the meaning of ζ and X directly from logic, such that: 1) quantization emerges in GR; 2) space, time, and quantization are treated uniformly across GR and QFT; 3) and both quantum and relativistic phenomena are fully described through classical reasoning. Thus, the equations of physics establish relationships between variables, and this framework establishes the ontological structure of our universe U in which those equations become unified. Since the mathematical theorems used in physics are also derived through classical logic [6], the entirety of modern physics is now derivable from classical logic as stated in the title (collectively derivable from eq. 73). This approach does not require strings, point particles, spacetime (standard meaning), higher dimensions, or controversial interpretations of quantum phenomena.

In the late 1950s to early 60s, Arnowitt, Deser, and Misner (ADM) developed the 3+1 formulation of GR [7], which decomposes spacetime into a family of three-dimensional hypersurfaces Σ_t parameterized by a global time coordinate t through a process known as *foliation*. The relationship between the ADM formalism, and the standard metric is

$$g_{\mu\nu} = \begin{pmatrix} -N^2 + N_k N^k & N_i \\ N_j & \gamma_{ij} \end{pmatrix}, g^{\mu\nu} = \begin{pmatrix} \frac{-1}{N^2} & \frac{N^i}{N^2} \\ \frac{N^j}{N^2} & \gamma^{ij} - \frac{N^i N^j}{N^2} \end{pmatrix}$$

where N is the lapse function, N^i is the shift vector, and γ_{ij} is the (generally non-Euclidean) three-dimensional metric of Σ_t [8]. As previously stated, the concepts of X and ζ are derived through logic which is done in Section 6, and so the following illustrates the process of making the ontology and the equations cohesive. Rather than treating time ζ as a physical dimension, we are going to treat it as an intrinsic property, similar to how charge is intrinsic to an electron. The justification for this interpretation of time, and the reason why it doesn't violate conservation laws, is established in Sections 2, 6, and 8. Within this initial context, only the spatial slice Σ_ζ exists, and the equations of GR describe how it evolves. To also make this ontologically compatible with QFT, it is necessary to introduce a quantized medium M (all scientific predictions are preserved, and the Michelson-Morley [9] results are adhered to). This quantized medium is universally confined to $\mathbb{R}^3$, and phenomena that are traditionally attributed to the curvature of Σ_ζ, are now attributed to the density of the medium (coupling terms are accounted for). This medium now forms the causal mechanism for both quantum and relativistic phenomena. It is this universal structure U, in which physics is unified mathematically and logically, exclusively confined to $\mathbb{R}^3$. It should be clarified that within this model, space and time are fundamentally decoupled, with time treated ontologically as a property rather than a dimension. This permits the continued use of a 4-D metric as a representational tool for describing the evolution of a 3-D universe, as further clarified in the text.

Every coherent field of study begins with a set of axioms and employs a logic to derive conclusions [6, 10, 11], represented schematically as

$$\{Axioms\} \xrightarrow{\text{Logic}} \{Conclusions\}. \tag{1}$$

According to Wilce [12] and Schurz [13], there isn't a single unifying logic from which the entirety of modern physics can be collectively understood. According to the definition of formal systems by Smullyan [10], without a unifying logic there isn't any way to form non-mathematical conclusions (e.g., ontology, explanations) within physics that give a coherent description of reality across all theories. Consequently, physicists often utilize a mathematics-first approach [14, 15], represented schematically as

$$\{Assumptions\} \xrightarrow{\text{Mathematics}} \{Predictions\}, \tag{2}$$

which can ensure that individual theories are mathematically consistent but does nothing beyond this to establish a more complete picture of our reality. While some argue that mathematical accuracy is the sole criterion for a physical theory, such a position is vulnerable on two fronts: 1) any theory devoid of ontological coherence is susceptible to being superseded by one that preserves the same numerical predictions within a unified framework; and 2) establishing the universal structure logically, prior to applying the mathematics, eliminates much of the guesswork resulting in greater efficiency that isn't utilized by those taking the mathematics-first approach. This framework addresses the aforementioned issues by establishing a single logic from which the entirety of modern physics is coherently understood (Method 1), and then applying mathematics (Method 2) to produce theories that are both numerically accurate and coherent. To clarify this, it isn't that the universe doesn't make sense, it is that, according to the collective implications made by Wilce, Schurz, and Smullyan, the necessary methods to coherently describe it were never established. For this reason, equations, and scientific observations can be assumed, but interpretive frameworks within physics cannot be.

For an entity such as an electron to exist, it must posses an intrinsic property that would permit it to be distinguishable from non-existence. This is a rather obvious definition that parallels a tautology, so I don't expect an objection. If you claim that an electron is an "excitation of a field" [16] then the field exists, and the word "electron" becomes descriptive of it. An imagined entity doesn't exist; instead, we would say that the neurons in your brain exist, and your brain permits you to imagine concepts and ideas that don't themselves exist in reality. Thus, existence is defined through intrinsic properties using the biconditional in Statement 8. Since everything studied within physics has a property, Statement 8 determines how all theories in physics must be constructed (physics studies existence). For example, information is a property and thus it requires existence; if the wave function is said to contain the information of a system [4], there must be an ontologically real mechanism that the mathematics describes and of which the information is a property. If you measure an entity, this means that you are interacting with at least one of its properties and therefore it exists; it follows that realism [17] must always hold even in light of Bell's theorem (discussed below). Notice that mathematics doesn't have an intrinsic property, and thus mathematics doesn't exist, nor can it be a causal agent ($d = v \cdot t$ describes the motion of a car but doesn't cause it to move).

If we utilize mathematics to describe the universe, we must assume that mathematical operations correspond to physical ones; for instance, $d = v \cdot t$ is only meaningful if the mathematical symbols and variables represent the actual displacement of an object. By defining existence through Statement 8, we can resolve the $0 \cdot \infty$ indeterminate form by identifying which mathematical operations describe real physical operations and which ones do not. This provides the logical basis for demonstrating why limits and the Dirac delta function cannot be validly applied to point particles or strings, ensuring that such entities can't be distinguished from non-existence, as further detailed in Section 6.

Mathematics [6], ontology (using Statement 8), explanations for phenomena (using ontology), and (now) physics are all axiomatic systems. By using the same logic throughout, it is possible to form a single axiomatic system that incorporates all methods that we have of understanding reality; such system is presented in Section 6, and aligns with Hilbert's Sixth Problem [18] but extends well beyond it. For this reason, any objection to the conclusions within this framework must either deny a scientific observation (discussed in Section 6) or demonstrate a foundational error within the fields of logic or mathematics.

To fully appreciate this framework, it is necessary to understand the implications of **Bell's theorem** [19]. In 1964, John Bell derived what are now known as Bell-type inequalities, which any theory satisfying both locality and realism must obey [19]. When the quantum correlation function is applied, for certain entangled states these inequalities don't hold, and these predictions have been experimentally confirmed without loopholes [20]. This establishes that any theory reproducing all quantum predictions must abandon either locality or realism, a point on which Maudlin argues in favor of realism [17]. To clarify this, a common analogy was to say that entanglement is like two different colored socks placed in separate boxes, and simply by opening one box you know the color of the other sock without a transfer of information [21]; Bells theorem eliminates these types of explanations [19], forcing you to choose between locality and realism (there are conceptual workarounds like retro-causality [22], which are discussed in Section 8). As stated above, realism must always hold, and thus it is locality that must be abandoned. Since the speed of light is built into the geometry of spacetime [3], GR is a local theory [19], and thus experimental violations of Bell's theorem eliminated spacetime as an ontologically accurate model (discussed further in Section 8). The universal structure U uses similar equations to those of GR, but avoids this issue as described in Section 2.

Notation. All 4-D metrics will be interpreted using the $(-,+,+,+)$ signature, where the notation $X^{(z)}_{\mu\nu}$ indicates that $X_{\mu\nu}$ is defined with respect to the metric $z_{\mu\nu}$.

2 Foundational Equations

These definitions and equations are established based on their derived meaning in section 6, and are stated here without proof. The field equations of modern physics are aligned with these equations in Sections 3 and 4, preserving their numerical predictions but establishing a coherent universal ontology.

Property (σ): An intrinsic attribute of an entity (real or otherwise) that is independent of the mind and geometrical characteristics. For any property σ and entity Z,

$$P_\sigma(Z) \in [0,1] \tag{3}$$

where $P_\sigma(Z) = 1$ signifies that Z has the property σ, and $P_\sigma(Z) = 0$ signifies that it doesn't. The value of each property, as a function of time and space is established as follows (see def. of Mathematics).

$$pos : Time \times Z \to \vec{x} \in Space \tag{4}$$

$$V : \sigma \to \mathbb{R} \tag{5}$$

$$\mathcal{M} : (t,\vec{x}) \in Time \times Space \to \mathbb{R} \tag{6}$$

$$\mathcal{M}_\sigma(t,\vec{x}) = \sum_{Z_i \mid pos(t,Z_i)=\vec{x}} V_\sigma(\sigma(Z_i)) \tag{7}$$

Existence (E): Defined through the biconditional

$$P(Z) \iff E(Z) \tag{8}$$

where $P(Z) = max\{P_\sigma(Z)\}$ (an electron exists).

Mathematics and $Space$: Let $Space$ be the geometry in which all entities are spatially defined, such that

$$Space \cong \mathbb{R}^n \tag{9}$$

for some $n \geq 3$. Furthermore, $\forall \vec{x}_n \in \mathbb{R}^n$ and $\forall \vec{x}_s \in Space$,

$$\vec{x} = \vec{x}_n = \vec{x}_s, \tag{10}$$

with the mathematical Euclidean space overlaying our reality. Each mathematical symbol, field, tensor, set, operator, function, and variable used, must correspond to some element in the set

$$AE = \{Z \mid E(Z) \neq 0\} \quad \text{(All Existence)} \tag{11}$$

or distance within $Space$. For example, the operation of physically taking two object and combining them is represented by the mathematical operation of $1 + 1$.

Universal Structure (U): Let $\mathcal{G}(t,\vec{x}) \subset Space$, represent the geometry of the observable universe (with no implications of spacetime). Let $M(t,\vec{x})$ be defined as the restriction of $\mathcal{M}(t,\vec{x})$ over $\mathcal{G}(t,\vec{x})$, in which only elements that are both quantized and have the property of time (see eq. 21) are selected:

$$M(t,\vec{x}) := \mathcal{M}(t,\vec{x}) \restriction_{\mathcal{G}(t,\vec{x})} \restriction_{Q \cap T} \tag{12}$$

$$Q := \{Z \mid \forall\sigma,\ V_\sigma(\sigma(Z)) = nk_\sigma,\ n \in \mathbb{Z}\} \tag{13}$$

$$T := \{Z \mid Time \in \{\sigma(Z)\}\}. \tag{14}$$

The universal structure U can thus be defined as an ordered pair, as a reminder that $\mathcal{G}(t,\vec{x})$ is the geometry of $M(t,\vec{x})$,

$$U = (\mathcal{G}(t,\vec{x}), M(t,\vec{x})). \tag{15}$$

Objects (O_x), Interactions (I), Measurability (δ), Wave-Function ($\Psi^U_{\mathcal{P}}$): An entity is considered an object if it is technologically measurable (this is just a classification) independent of proximity (a rock in $Space$ is still an object simply because we have the ability to measure rocks). Since AE constitutes all that exists, Z is either measurable, or an interaction results in a measurable property. Thus, define an interaction between some subset $\{Z_i\}_{i=1}^j \subset AE$ as

$$I_{\{Z_i\}_{i=1}^j}(t,\vec{x}) = M(t,\vec{x}) \restriction_{\{pos(t,Z_i)\}_{i=1}^j}. \tag{16}$$

This equation represents all information about the system, and is thus referred to as the wave-function of the interaction, represented as

$$\Psi^U_{\{Z_i\}_{i=1}^j}(t,\vec{x}) = I_{\{Z_i\}_{i=1}^j}(t,\vec{x}). \tag{17}$$

By definition, it follows that the set O of all objects, is the set of all wave functions that have a measurable magnitude,

$$O = \{\Psi^U_{\{Z_i\}_{i=1}^j}(t,\vec{x}) \mid |\Psi^U_{\{Z_i\}_{i=1}^j}(t,\vec{x})| \geq D_{\{Z_i\}_{i=1}^j}\}, \tag{18}$$

where $D_{\{Z_i\}_{i=1}^j}$ is the minimal detectable value, set by the limits of current technology. Thus, let $\mathbb{P}$ be the set of all (measured) particles. It follows that:

$$\mathbb{P} \subset O. \tag{19}$$

In QM, the wave-function $\Psi_{\mathcal{P}}(t,\vec{x})$ is used to statistically model a particle $\mathcal{P}$ [4, 5], while the exact state within U is just that of eq. 17. When appropriate, the $\Psi^U_{\mathcal{P}}(t,\vec{x})$ notation will be used to represent both the measurable and unmeasurable states of the particles components. The exchange between measurable and unmeasurable states is represented as

$$Ex : \Psi^U_{\mathcal{P}}(t,\vec{x}) \to \{Meas., Unmeas.\}. \tag{20}$$

Closed Time-Like Curves ($S_Z(t)$): Closed time-like curves (CTC) have been investigated by physicists like Godel [23] and Friedman [24]. Instead of the CTC being defined in spacetime, within U they are causal loops intrinsic to Z, to the same extent that charge is an intrinsic property of an electron (in the standard model [5]). Thus

$$Time \in \{\sigma(Z)\}, \quad (\text{In } U). \tag{21}$$

A CTC satisfies the following definitions

$$s_{\alpha Z} : Time \to Intrinsic\_State \tag{22}$$

$$S_Z := s_{\alpha Z}(t) \in C(-\infty,\infty), \quad \alpha \neq \alpha(t), \quad \alpha \in \mathbb{R} \tag{23}$$

where $-\infty$ is used in the domain to signify that Z has always existed, and α quantifies the property by which Z changes states. In the case that $\alpha = const$, then the intrinsic state of Z is deterministic, but if α varies, since it is not a function of time, it would represent the property of bounded free will. Informally, think of each state as a road and time as the engine, where α determines which road Z is on. There are no implications made that the property of free will is possible.

The operator $*$ denotes the compositional aggregation of the intrinsic state functions, where the resulting value represents the net available internal state freedom of the system, defined as:

$$S_{\{Z_i\}_{i=1}^j}(t) = S_{Z_1}(t) * S_{Z_2}(t) * \ldots S_{Z_j}(t) \tag{24}$$

where $S_{\{Z_i\}_{i=1}^j}(t)$ drives the interaction, represented as

$$S_{\{Z_i\}_{i=1}^j}(t) \xrightarrow{Drives} \Psi^U_{\{Z_i\}_{i=1}^j}(t,\vec{x}). \tag{25}$$

Each Z intrinsically produces internal changes that result in interactions, and those interactions give Z spatial variance that produce the statistical outcomes of QM. Furthermore, $Space$ and time are now ontologically decoupled.

Proper Time (τ), Reference Frame (RF): Let $A, B \subset \mathcal{G}$. The complete respective reference frames are

$$RF_A(t,\vec{x}) = M(t,\vec{x}) \restriction_A,\ RF_B(t,\vec{x}) = M(t,\vec{x}) \restriction_B \tag{26}$$

(see def. of CTC) and the proper time [3] in each reference frame $X \in \{A, B\}$ is a measurement of

$$\Delta\tau_X : RF_X(t_{X2},\vec{x}_{X2}) \times RF_X(t_{X1},\vec{x}_{X1}) \to \mathbb{R}, \tag{27}$$

where time dilation [3] occurs when $\Delta\tau_A \neq \Delta\tau_B$ over the same Δt. For a photon γ in the RF_X reference frame

$$\gamma = \Psi^U_{\{Z_i\}_{i=1}^j} = RF_X \restriction_{\{pos(t,Z_i)\}_{i=1}^j} \tag{28}$$

and thus the speed of light is

$$c(\tau) = \frac{\|(pos(t_{X2},\gamma) - pos(t_{X1},\gamma))\|}{\Delta\tau_X} = const \tag{29}$$

$$c(t) = \frac{\|pos(t_{X2},\gamma) - pos(t_{X1},\gamma)\|}{\Delta t}| \neq const \tag{30}$$

ensuring that the speed of light is measurably invariant. It should be noted that the metric of $\mathcal{G}(t, \vec{x})$, denoted as $\chi_{ij}^{(\mathcal{G})}$, need not be Euclidean, and in such cases

$$\|pos(t_{X2}, \gamma) - pos(t_{X1}, \gamma)\| \to \sqrt{\chi_{ij}^{(\mathcal{G})} dx^i dx^j}. \quad (31)$$

From eqs. 29 and 30, it follows that the concepts of time within GR and U are related by

$$c\Delta\tau = c(t)\Delta t. \quad (32)$$

Non-Locality (NL): Using eq. 29, with γ replaced by Z, yields

$$\frac{\|\Delta\vec{x}_Z\|}{\Delta\tau} = \frac{\|pos(t_{X2}, Z) - pos(t_{X1}, Z)\|}{\Delta\tau}. \quad (33)$$

If Z is presumed to be unmeasurable, there is no known bound to eq. 33 (the speed of light is fundamentally built into the geometry of spacetime [25] but such is not the case with $\mathcal{G}(t, \vec{x})$). Even if eq. 33 had a value many orders of magnitude that of c, it would not result in causal violations (cause must precede effect [25]), as information being obtained from Z before γ doesn't produce a paradox. Non-locality [19] can thus be defined, without violating causality, as an interaction that occurs faster than light (FTL), represented as

$$Non-local(\mathcal{P}) \iff \exists Z(\|\frac{dpos(t, Z)}{d\tau}\| > c). \quad (34)$$

Equations of relativity only pertain to objects, thus avoiding complex times.

Laws of Existence (LOE): The complete set of ontological rules by which everything that exists can be coherently understood (derivable using eq. 8). *These laws are not imposed constraints on how the universe operates, but rather necessary conditions ensuring that all methods of analyzing reality (mathematics, science, philosophy) employ consistent rules of inference.*

3 M And The Metric Of $\mathcal{G}$

To reproduce the same physics as γ_{ij} (which doesn't include coupling terms) within U, it is necessary to express γ_{ij} as the contraction of a mixed tensor ρ_i^k with the metric of $\mathcal{G}$, namely $\chi_{kj}^{(\mathcal{G})}$. This relation is

$$\underbrace{\gamma_{ij}}_{\text{geometry of } \Sigma_t} = \frac{1}{\epsilon} \underbrace{\rho_i^k \chi_{kj}^{(\mathcal{G})}}_{\text{prop. dens. of } M \text{ in } \mathcal{G}} \quad (35)$$

where $|\epsilon| = 1$, and $[\epsilon] = \frac{[Z]}{dist^5}$. Thus, the spatial relations defined by the metric γ_{ij}, are attributed to the property density of the M field within $\mathcal{G}$. Explicitly defining $\mathcal{G}$ to be $\mathbb{R}^3$ Euclidean (which is not required in general), the effective metric ρ_{ij} within U is equal to the effective metric γ_{ij} within spacetime (aside from units), thus preserving the numerical predictions, changing only the ontology.

$$[\chi_{kj}^{(\mathcal{G})} = \delta_{kj}] \implies \frac{1}{\epsilon} \underbrace{\rho_{ij}}_{\text{Metric in } U} = \underbrace{\gamma_{ij}}_{\text{Metric in GR}} \quad (36)$$

Since $Time \in \{\sigma(Z)\}$, space and time are ontologically decoupled regardless of the mathematics. That is, $\forall\mu, \nu \in \{0, 1, 2, 3\}, g_{\mu\nu}$ describes U (all components of the metric are either positions in $\mathcal{G}$, or describing properties of the M field). This allows us to keep the coupling terms, to recover phenomena such as frame dragging, and to **use the 4-D spacetime metric to describe the 3-D universe**. The metric of U can thus be established as

$$\rho_{\mu\nu} = \underbrace{\begin{pmatrix} \epsilon(-N^2 + N_k N^k) & \epsilon N_i \\ \epsilon N_j & \rho_{ij} \end{pmatrix}}_{\text{All components of } U}, \quad (37)$$

where

$$\rho_{\mu\nu} = \epsilon g_{\mu\nu}. \quad (38)$$

Again, these equations are not just scaled, the entire ontology is distinct. To transition between time within GR and time within U, eq. 32 is used yielding the following metric equation

$$\underbrace{-\epsilon c(t)^2 dt^2}_{\text{comp. of } U} = \underbrace{\rho_{\mu\nu} dx^\mu dx^\nu}_{\text{comp. of } U}. \quad (39)$$

Using eqs. 29-30

$$-dM^2 = \rho_{\mu\nu} dx^\mu dx^\nu. \quad (40)$$

These equations therefore parallel those of Einstein, but with the axiomatically derived concept of time, the physics is modeled within U instead of spacetime. **These equations can only be confirmed to apply to objects, thus complex times are avoided.**

4 The Field Equations

The following equations pertain to the gravitational, scalar, fermion, and gauge fields, respectively. The original expressions of each equation, denoted by $X^{(g)}$, are referenced in their corresponding sections. The first two fields are general enough that details are left out.

Gravity (Original forms: [3, 8]):

$$\Gamma^{(\rho)\mu}_{\nu\sigma} = \frac{1}{2}\rho^{\mu\lambda}\left(\partial_\nu\rho_{\sigma\lambda} + \partial_\sigma\rho_{\nu\lambda} - \partial_\lambda\rho_{\nu\sigma}\right) \tag{41}$$

$$= \Gamma^{(g)\mu}_{\nu\sigma} \tag{42}$$

$$R^{(\rho)}_{\mu\nu} = \partial_\alpha\Gamma^{(\rho)\alpha}_{\mu\nu} - \partial_\nu\Gamma^{(\rho)\alpha}_{\mu\alpha} + \Gamma^{(\rho)\alpha}_{\beta\alpha}\Gamma^{(\rho)\beta}_{\mu\nu} - \Gamma^{(\rho)\alpha}_{\nu\beta}\Gamma^{(\rho)\beta}_{\mu\alpha} \tag{43}$$

$$= R^{(g)}_{\mu\nu} \tag{44}$$

$$R^{(\rho)} = \rho^{\mu\nu}R^{(\rho)}_{\mu\nu} \tag{45}$$

$$= \frac{1}{\epsilon}R^{(g)} \tag{46}$$

$$\mathcal{L}^{(\rho)}_{EH} = \frac{1}{16\pi G}R^{(\rho)}\sqrt{-\rho} \tag{47}$$

$$= \epsilon\mathcal{L}^{(g)}_{EH} \tag{48}$$

Scalars (Original forms: [16]):

$$\mathcal{L}^{(\rho)}_{\phi} = -\frac{1}{2}\sqrt{-\rho}(\rho^{\mu\nu}\partial_\mu\phi\partial_\nu\phi + \frac{1}{\epsilon}m^2\phi^2) \tag{49}$$

$$= \epsilon\mathcal{L}^{(g)}_{\phi} \tag{50}$$

Fermions: This section is based on the work of Alcubierre [26], but with $g_{\mu\nu}$ replaced by $\rho_{\mu\nu}$ in accordance with this framework. The vierbeins are a set of four orthonormal vectors e^μ_A defined at each point of spacetime, forming a local basis, where the index $A = 0, 1, 2, 3$ labels the directions. The relationships between $\rho_{\mu\nu}$, $g_{\mu\nu}$, $\eta_{\mu\nu}$ and e^μ_A are:

$$\rho_{\mu\nu}e^\mu_A e^\nu_B = \epsilon\eta_{AB} \iff g_{\mu\nu}e^\mu_A e^\nu_B = \eta_{AB} \tag{51}$$

so the unit conversion factor ϵ doesn't change the vierbeins. The raising and lowering of indices μ, ν and A, B are done with $g_{\mu\nu}$ and $\eta_{\mu\nu}$ respectively, represented as

$$\epsilon e_{\mu A} = \rho_{\mu\nu}e^\nu_A \iff e_{\mu A} = g_{\mu\nu}e^\nu_A \tag{52}$$

$$\epsilon e^{\mu A} = \epsilon\eta^{AB}e^\mu_B \iff e^{\mu A} = \eta^{AB}e^\mu_B. \tag{53}$$

Starting with the scaled gamma functions:

$$\{\frac{\gamma^A}{\sqrt{\epsilon}}, \frac{\gamma^B}{\sqrt{\epsilon}}\} = -2\frac{1}{\epsilon}\eta^{AB}\mathbf{I}_4 \tag{54}$$

$$= -2\eta^{AB}_{(\epsilon)}\mathbf{I}_4, \tag{55}$$

where $\eta^{AB}_{(\epsilon)}$ signifies the scaled Minkowski metric, and using the relation $\gamma^\mu = \gamma^A e^\mu_A$, yields

$$\{\frac{\gamma^{(g)\mu}}{\sqrt{\epsilon}}, \frac{\gamma^{(g)\nu}}{\sqrt{\epsilon}}\} = -2\frac{1}{\epsilon}\eta^{AB}e^\mu_A e^\nu_B\mathbf{I}_4 \tag{56}$$

$$= -2\frac{1}{\epsilon}g^{\mu\nu}\mathbf{I}_4 \tag{57}$$

$$= -2\rho^{\mu\nu}\mathbf{I}_4. \tag{58}$$

The relationship between $\bar{\Psi}$ and Ψ must remain the same, and thus

$$\bar{\Psi} = \Psi^\dagger\gamma^{(\eta_\epsilon)0}\sqrt{\epsilon}. \tag{59}$$

Since the vierbeins do not change, neither does the spin-connection

$$\omega_{AB\mu} = e^\nu_B(e_{\lambda A}\Gamma^\lambda_{\mu\nu} - \partial_\mu e_{\nu A}), \tag{60}$$

and thus the Spinor covariant derivatives are related as follows:

$$\frac{D^{(g)}_\mu\Psi}{\epsilon} = \frac{1}{\epsilon}\partial_\mu\Psi - \frac{1}{4}\omega_{AB\mu}\frac{\gamma^A}{\sqrt{\epsilon}}\frac{\gamma^B}{\sqrt{\epsilon}}\Psi = D^{(\rho)}_\mu\Psi. \tag{61}$$

Thus, the relationship between Lagrangian's is:

$$\mathcal{L}^{(\rho)}_{\Psi} = \sqrt{-\rho}\bar{\Psi}(i\sqrt{\epsilon}\gamma^{(\rho)\mu}D^{(\rho)}_\mu - \frac{1}{\epsilon}m)\Psi \tag{62}$$

$$= \epsilon\mathcal{L}^{(g)}_{\Psi}. \tag{63}$$

Gauge (Original forms: [27, 28]): Let the covariant form of the Yang-Mills field strength be represented as $F^{(g)}_{\mu\nu}$. Scaling $g_{\mu\nu}$ by the constant ϵ, can only change the relationship between $F^{(\rho)}_{\mu\nu}$ and $F^{(g)}_{\mu\nu}$ by some exponent of ϵ, represented as

$$F^{(\rho)}_{\mu\nu} = \epsilon^n F^{(g)}_{\mu\nu}. \tag{64}$$

Then

$$F^{(\rho)\mu\nu} = \epsilon^{n-2}F^{(g)\mu\nu} \tag{65}$$

therefore:

$$\mathcal{L}^{(\rho)}_{YM} = -\frac{1}{2g^2_{YM}\epsilon^{2n-1}}\sqrt{-\rho}\,tr(F^{(\rho)}_{\mu\nu}F^{(\rho)\mu\nu}) \tag{66}$$

$$= -\frac{1}{2g^2_{YM}\epsilon^{2n-1}}\epsilon^2\sqrt{-g}\,tr(\epsilon^n F^{(g)}_{\mu\nu}\epsilon^{n-2}F^{(g)\mu\nu}) \tag{67}$$

$$= \epsilon\mathcal{L}^{(g)}_{YM} \tag{68}$$

where n is determined by the field being analyzed.

5 A Quantum Gravity Concept

The variation of the action equation $\delta(\int_{GR} d\tau) = 0$ [8], in conjunction with eq. 39, establishes that the geodesics within spacetime and U are the same. However, $Ex(\mathcal{P})$ (eq. 20) establishes that a particle is not guaranteed to always be measurable, so we need a conceptual starting point using the geodesic equation, represented as

$$\underbrace{\frac{d^2\Psi^{U\mu}_{\mathcal{P}}}{d\tau^2} + \Gamma^{(\rho)\mu}_{\alpha\beta}\frac{d\Psi^{U\alpha}_{\mathcal{P}}}{d\tau}\frac{d\Psi^{U\beta}_{\mathcal{P}}}{d\tau} = F^\mu(S_{\mathcal{P}}(t)),}_{\text{Conceptual starting point}} \tag{69}$$

where $F^{\mu}(S_{\mathcal{P}}(t))$ is an intrinsically driven acceleration resulting in $\mathcal{P}$ deviating from the standard geodesic. Let's temporarily treat M as a fixed medium having a varying index of refraction (IOR) $n = \frac{c}{c(t)}$, where the motion of $\mathcal{P}$ parallels the curving of a photon (photons curve towards the higher IOR [29]). As $\mathcal{P}$ moves radially away from a gravitational field, its path would curve towards the higher IOR. When moving in the opposite direction, the path of $\mathcal{P}$ would be more direct for the same reason. Therefore, as $\mathcal{P}$ moves, on average its radial displacement away from the source of gravity is less than its radial displacement towards the source, and this manifests as gravity. As particles combined to form a single object

$$O_x = \Psi^{U}_{\{\mathcal{P}_i\}_{i=1}^{k}}, \tag{70}$$

the tangential components (from curving) statistically cancel, leaving only the radial force that we observe. Thus, the geodesic within U is

$$\underbrace{\frac{d^2 O_x^{\mu}}{d\tau^2} + \Gamma^{(\rho)\mu}_{\alpha\beta} \frac{dO_x^{\alpha}}{d\tau} \frac{dO_x^{\beta}}{d\tau} = F^{\mu}(S_{O_x}(t)),}_{\text{Geodesic of object } O_x} \tag{71}$$

subject to

$$\lim_{k\to\infty} F^{\mu}(S_{O_x}(t)) = 0, \tag{72}$$

thus recovering the geodesic of GR.

6 The Axiomatic System

For a theoretical statement or claim X to be coherent, it must be derivable within some axiomatic system $(\Sigma, \vdash_L)$ in which a contradiction can't be derived ($\Sigma \nvdash_L \bot$), but X itself is derivable ($\Sigma \vdash_L X$) [10, 11]. Formally,

$$Coherent(X) \iff \exists(\Sigma, \vdash_L)\big[(\Sigma \nvdash_L \bot) \wedge (\Sigma \vdash_L X)\big].$$

Logic is the study of valid reasoning, and is independent of the specific axioms used. To clarify this, since $X \vdash_L X$ [10], X makes sense within the formal system $(X, \vdash_L)$. However, if X is not true it is not dependable for understanding reality. What is therefore necessary is to establish a formal system in which all of the axioms are true, and in which all methods used to analyze reality can be derived. We are thus looking for an axiomatic system that incorporates the following,

$$\underbrace{(\Sigma_{\text{math}}, \vdash_L)}_{\text{Theorems}} \sqcup \underbrace{(\Sigma_{scie}, \vdash_L)}_{\text{Science}} \sqcup \underbrace{(\Sigma_{\text{onto}}, \vdash_L)}_{\text{Ontology}} \sqcup \underbrace{(\Sigma_{\text{phil}}, \vdash_L)}_{\text{Philosophy}}$$

where the axioms are defined and clarified as follows:

Σ_{math} = {All non-logical axioms such that when analyzed using the logical system L, all of the mathematical theorems used in physics can be derived.}. While Zermelo Frankel Set Theory (ZFC) [6] is an ideal choice, it is not necessary to impose further restrictions.

L = Classical Logic (dictated by the mathematics). Although a variety of logical systems can be employed to develop different branches of mathematics, the Law of Excluded Middle (LEM), a fundamental axiom of classical logic, underpins many mathematical proofs, including proofs by contradiction [6]. Furthermore, the overlaying of Euclidean space and reality (see def. of Mathematics and $Space$), demands that the operations of reality be explained using the logic of the mathematics.

Σ_{scie} = {All scientifically confirmed observations (all scientific fields).} These represent the *observations themselves*, independent of any theoretical or interpretative framework. The logic L then tells us how to construct models so that all observations are coherently explained.

$\Sigma_{onto} = \{P(Z) \Leftrightarrow E(Z), \{\sigma\}\}$. *Let $Y = \{y \mid y$ is a point on an imagined sphere ζ in $Space\}$. The act of imagining ζ does not produce any change at Y that would distinguish reality at Y from reality at $k \notin Y$ (unless an existence is moved to Y). For this reason, the definition of properties must exclude that which is confined to the mind. Moreover, since the points of Y are still part of reality, geometric attributes must also be excluded from the definition of properties. That is, conceptualization and geometric attributes are not sufficient to declare existence.* This permits us to develop physics with a clear distinction between what exists and what doesn't.

$\Sigma_{\text{phil}} = \Sigma_{\text{onto}} \cup \Sigma_{\text{scie}} \cup \Sigma_{\text{conc}}$. All philosophical reasoning must be consistent with the rules of ontology and carried out in light of established scientific observations. This structure permits the incorporation of new conceptual elements Σ_{conc}, provided that they remain compatible with the existing axioms. In this sense, any claim not ruled out by the logic L, ontology, scientific observation, or mathematics, leaves no justification for objection and is thus permitted within this framework.

The axiomatic structure introduced here is intended to provide a unifying logical framework for describing physical theories. It synthesizes concepts drawn from established developments in science, mathematics, philosophy, and logic, and for this reason I refer to it as the Framework of Everything (FOE), a formal system that I first published in 2024 with initial concepts published in 2023. The FOE is not a replacement for existing scientific knowledge; rather, it is an organizational structure designed to incorporate and relate that knowledge within a single coherent axiomatic system. The FOE can now be formally established.

$$FOE = \left(\Sigma_{\text{math}} \cup \Sigma_{\text{scie}} \cup \Sigma_{\text{onto}} \cup \Sigma_{\text{phil}},\ \vdash_L\right), \quad (73)$$

Classical logic has a well defined implication and contrapositive, but the converse isn't always true [10]. Thus, for any specific property s, and any entity Z, if Z is not defined by s (the electron is defined to have charge), the following holds:

(i) $P_s(Z) \implies E(Z)$: If entity Z possesses the property of s, then Z must exist.

(ii) $\neg E(Z) \implies \neg P_s(Z)$: If entity Z does not exist, then it cannot possess the property of s.

(iii) $\neg(E(Z) \implies P_s(Z))$: It is not the case that the existence of Z implies that Z possesses the specific property of s.

Law of Interaction. The following criterion determines whether an entity Z possesses the property of interaction $\mathcal{I}$, and $s = \mathcal{I}$ in (i)-(iii) are the ontological rules:

$$\mathcal{I} \in \{\sigma(Z)\} \iff \exists Z_i(|\Psi^U_{\{Z_i,Z\}}(t,\vec{x})| \neq 0). \quad (74)$$

It follows that if Z is measurable, then Z exists; and that we can consider that Z exists even if Z isn't measurable. This establishes that realism [17] always holds, and that the $\mathcal{M}$ field need not be testable. It should be clarified that the interaction need not occur, only that Z and Z_i both exist.

Law of Self-Causation: The following criterion determines whether an entity Z possesses the property of self-causation $\mathcal{S}$, and $s = \mathcal{S}$ in (i)-(iii) are the ontological rules:

$$\mathcal{S} \in \{\sigma(Z)\} \iff \exists\, \mathbf{t}(\mathbf{t} \in D_{S_Z} \wedge S_Z(\mathbf{t}) \neq 0). \quad (75)$$

*This establishes that if an entity doesn't exist, it can't cause itself to exist; and that causal motion, what we associate with **time**, can either be an intrinsic property or a result of external factors. As stated in Section 1, violations of Bell's inequality establishes that time isn't a result of external factors like the curvature of spacetime, and thus time t must be an intrinsic property.*

Laws of Ontological Continuity:

Claim: The totality of existence is fixed, and all creations are permutations thereof.

Proof: By the Laws of Self-Causation and Interaction,

$$[P_{\mathcal{S}}(Z) \implies E(Z)] \wedge [P_{\mathcal{I}}(Z) \implies E(Z)] \quad (76)$$

which simplifies to

$$P_{\mathcal{S}}(Z) \vee P_{\mathcal{I}}(Z) \implies E(Z). \quad (77)$$

If Z can begin to exist from non-existence (not created from something else that exists), then, by the LEM, the existence of Z must either begin intrinsically or extrinsically. Thus:

$$CanBeginE(Z) \implies P_{\mathcal{S}}(Z) \vee P_{\mathcal{I}}(Z) \quad (78)$$

$$\therefore CanBeginE(Z) \implies E(Z), \quad (79)$$

It follows that if Z can begin to exist, then it already exists, contradicting the claim that it can begin to exist. That is

$$\neg E(Z) \implies \neg CanBeginE(Z) \quad (80)$$

$$\therefore \neg CanBeginE(Z). \quad (81)$$

Let $AlwaysE(Z)$ be the statement "Z has always existed." If Z exists, since it can't begin existing, it must have always existed, represented as:

$$E(Z) \implies AlwaysE(Z) \quad (82)$$

Let $PreZ(O)$ be the statement "Object O is created from pre-existing (Z) entities." If object O is created, then $CanBeginE(O)$ is true. Thus, the premise that Z (now O) isn't created from pre-existing entities must be false. It follows that:

$$Created(O) \implies PreZ(O) \quad (83)$$

QED

Law of Spatial Isomorphism:

$Space$: The closed and connected geometry in which everything that exists, exists.

Claim: $Space \cong \mathbb{R}^n$ for some $n \geq 3$, permitting unimpeded traversal.

Proof: Let $Space \cong X \subsetneq \mathbb{R}^n$ where $dim(X) = n$. By definition $Space$ doesn't exist ($\neg E(Space)$), thus the set of properties of $Space$ are equal to the set of properties exterior to $Space$,

$$\{\sigma(Space)\} = \{\sigma(Ext.Space)\} \quad (84)$$

This establishes the isomorphism by contradiction, and

$$\neg E(Space) \implies \neg P_{\mathcal{I}}(Space) \quad (85)$$

establishes unimpeded traversal.
QED

6.1 The $0 \cdot \infty$ Indeterminate Forms

In standard mathematics, infinity represents the concept of being unbounded, and thus the notation $0 \cdot \infty$ is generally regarded as indeterminate [6]. However, by the Law of

Ontological Continuity, the magnitude of the past $\|T\|$ is infinite, not approaching infinite, and this concept is not captured within mathematical limits in which values can approach infinity. It is therefore necessary to adopt the notation $\|T\| = \infty$, and it is within this context that the following statements are made, where $\overline{\mathbb{R}} = \mathbb{R} \cup \{-\infty, +\infty\}$ denotes the extended real number line.

Axiom 1 (Law of Identity): $\forall x \in \overline{\mathbb{R}}$, $x = x$.

Thus $\infty \neq \infty + 1$, *as* $\|T\| = \infty$ *and* $\|T\| + 1 = \infty + 1$ *correspond to distinct values of* t. *It therefore follows that* $\frac{1}{\infty} \neq \frac{1}{\infty+1} \neq 0$, *but rather* $\frac{1}{\infty} \to 0$, *as infinity can be exceeded (existence has always existed and continues existing). To clarify this, if one begins walking at* $x = 0$, *regardless of how long they walk, they will have traveled a finite distance* d *represented as* $\|d\| < \infty$, *over the interval* $[0, d]$. *However, if they have always been walking, then their distance interval is* $[-\infty, 0) \cup [0, d]$ *in which* $\|d_{past}\| + \|d\| \geq \infty$, *where* d *is based on when the measurement started.*

Axiom 2 (Mathematical Representation of the Law of Onto. Cont.): $\forall x \in \overline{\mathbb{R}}$, $0 \cdot x = 0$.

It is not possible to take even an infinite number of entities that don't individually exist, and obtain non-existence, and thus $0 \cdot \infty = 0$ *is well-defined, subject to Axiom 3.*

Axiom 3 (Law of Mathematical Realism): Every mathematical operation permitted within physics, must correspond to a physical operation, or represent non-existence.

It is not possible to take something that doesn't exist and perform an operation with it. Thus, from $0 \cdot x = 0$, *with* $x \neq 0$, *one can write* $0 = \frac{0}{x}$ *(operation with existence), but can't write* $x = \frac{0}{0}$ *(operation with non-existence). Hence division by zero is nonsense because it doesn't correspond to anything in reality, whereas division by infinity does.*

Axiom 4 (Law of Inverses): $\forall x \in \overline{\mathbb{R}} \setminus 0$, $x \cdot x^{-1} = 1$.

From Axiom 1, $[\frac{1}{\infty} \neq 0] \cdot \infty = 1$, *and thus this holds even with infinities.*

Claim 1: If the limit of two functions is non-zero, then neither function becomes identical to zero in the limit.

Proof: Let $\lim_{x \to a} f(x) \to 0$, $\lim_{x \to a} g(x) \to \infty$, and $\lim_{x \to a} f(x)g(x) \neq 0$. By Axiom 2, it follows that $\lim_{x \to a} f(x)g(x) \neq [\lim_{x \to a} 0 \cdot g(x) = 0]$, to which we conclude that $\lim_{x \to a} f(x)$ can't be identical to zero, but rather becomes arbitrarily close to it. QED

Remark 1: This proof becomes rather intuitive using an example like $\lim_{x \to \infty} \frac{1}{x} \to 0$. Since $\nexists x \in \overline{\mathbb{R}} | 1 = 0 \cdot x$ (Axiom 2), the limit isn't identical to zero. In standard mathematics this distinction generally doesn't matter, but when dealing with specific "edge cases," the logic has to be remembered.

Remark 2: The Dirac delta function $\delta(x)$ is primarily motivated by taking the limit in which the width of the bell curve within the Gaussian distribution becomes zero [30]. By claim 1, the width of the bell curve (represented by $f(x)$) doesn't become identical to zero, and thus it can't apply to anything point-like. If we then analyze the formal definition of the Dirac delta function where $\delta(x - \alpha) = 0 \, \forall x \neq \alpha$, $\delta(x - \alpha) = \infty$ for $x = \alpha$, and $\int_{-\infty}^{\infty} \delta(x - \alpha)\, dx = 1$ [30], by Axiom 2, this is equivalent to defining $1 = 0$. Thus, while the Dirac delta function provides a powerful simplification tool, it doesn't pertain to anything in reality.

Remark 3: It follows from Axiom 2, Claim 1, and eq. 8, that point-particles and 1-dimensional strings do not have a property that could distinguish them from non-existence.

7 Results

A universal ontological structure U is derived in which space, time, and quantization are coherently described by the equations of GR and QFT. This ontological structure is derived from an axiomatic system called the FOE in which mathematics, ontology, (some) philosophy, and physics now share a common logic, thus establishing a means of making conclusions that remain consistent across different methods of understanding reality. Within U, quantization naturally emerges, providing the causal mechanism for both quantum and relativistic phenomena. With space and time decoupled (see def. Closed timelike curves), the 4-D metric describes behavior of a 3-D universe (U), thus requiring minimal changes to the field equations as follows:

$$
\begin{aligned}
c d\tau &= c(t) dt \quad \text{(eq. 31, time measured by } c(t)\text{)} \\
\rho_{\mu\nu} &= \epsilon g_{\mu\nu} \quad \text{(eq. 40)} \\
dM^2 &= \epsilon g_{\mu\nu} dx^\mu dx^\nu \quad \text{(eq. 42)} \\
\mathcal{L}_{EH}^{(\rho)} &= \epsilon \mathcal{L}_{EH}^{(g)} \quad \text{(eq. 54)} \\
\mathcal{L}_{\phi}^{(\rho)} &= \epsilon \mathcal{L}_{\phi}^{(g)} \quad \text{(eq. 56)} \\
\mathcal{L}_{\Psi}^{(\rho)} &= \epsilon \mathcal{L}_{\Psi}^{(g)} \quad \text{(eq. 69)} \\
\mathcal{L}_{YM}^{(\rho)} &= \epsilon \mathcal{L}_{YM}^{(g)} \quad \text{(eq. 74).}
\end{aligned}
$$

(THESE ARE NOT JUST SCALED)

Since, $Space$, time, and quantization are treated uniformly throughout all equations, coherent unification is established as

$$
\mathcal{L}_M^{(\rho)} = \mathcal{L}_{EH}^{(\rho)} + \mathcal{L}_{\psi}^{(\rho)} + \mathcal{L}_{\Psi}^{(\rho)} + \mathcal{L}_{YM}^{(\rho)} \tag{86}
$$

Thus, the entirety of modern physics has been reproduced within a 3-D Euclidean space (eq. 15).

8 Discussion Of This Framework

If spacetime is temporarily assumed for conceptual purposes, then spacetime must exist within $Space$. For spacetime to be distinguished, it therefore follows that it must ontologically exist, and not just represent a geometry. Let the time domain of spacetime be represented as

$$D_{S_{spacetime}(t)} = (-\infty, \infty) = \underbrace{(-\infty, a)}_{p_1} \cup \underbrace{[a, t_{\text{now}})}_{p_2}, \quad (87)$$

(see Eq. 23) where $\|p_1\| = \|p_2\|$. If one assumes the Big Bang, statistical mechanics [31] and natural causes, then either the Big Bang occurred in p_1 ($\|p1\|$ is infinite), or the universe is cyclic (e.g., Conformal Cyclic Cosmology (CCC) [32]), represented as

$$Began(spacetime, p_1) \vee Cyclic(spacetime). \quad (88)$$

The finite age of the observable universe [33] establishes that $\neg Began(spacetime, p_1)$, and so the universe can only be fully described through a cyclic model. In the CCC, the end of the universes cycle mathematically looks like the beginning, where the scale factor $a(t)$ is said to be lost as the universe expands [32]. However, by the Laws of Ontological Continuity, existence is fixed, so even if the universe expands indefinitely, the reference frame persists, ensuring that the scale factor can't vanish. Similarly, the mathematical fields of physics describe ontological fields, where ontological fields require physical mechanisms. Just saying that the beginning and the end of a universe mathematically look similar, is not sufficient to establish how or why the fundamental existences that formed the universe reset to form the next cycle. This complete universal cycle therefore cannot be driven by entropy, nor can entropy explain the one way direction of time (contrary to [34]). Treating time as a property resolves this problem conclusively, without introducing new complications.

Within a block-universe framework, all past, present, and future events are equally real, with the parameter t specifying the spacetime hypersurface corresponding to an observer's experienced moment [1]. However, under this interpretation, there is no principled explanation for why the universe should be describable by stable mathematical laws. If all events in spacetime are fixed and the role of t is merely to index experience, then no internal mechanism prohibits arbitrary configurations of matter and energy. In such a setting, there is no fundamental reason entropy could not decrease, stars could not spontaneously form in a local environment, or people spontaneously move through the sky. Appeals to anthropic reasoning where observers can only arise in sufficiently ordered universes, does not resolve this issue since in a fully fixed spacetime there is no logical obstruction to the spontaneous appearance of observers within highly disordered or catastrophic configurations. Consequently, the block-universe interpretation lacks an explanatory basis for the observed persistence of physical regularities and therefore fails to provide a coherent account of why the universe exhibits lawful structure. It therefore follows that we can't use concepts like retro-causality to save spacetime from the implications of Bell's theorem, because the very concept of spacetime itself is not coherent. Within U, the physical properties of our universe are needed to ensure that it evolves correctly, thus resolving this extensive oversight.

Is this framework overly simplistic? Simplicity here reflects logical consistency rather the the frameworks inability to adequately explain the universe. For example, although the detailed physical descriptions of dark matter and dark energy remain unknown, both are empirically inferred to exist and therefore fall within the ontological scope of the M field. In this sense, all objects or phenomena that physics may ever discover are, by definition, contained within M. The perceived complexity of modern physics arises not from the richness of nature, but from logical inconsistencies embedded in its foundational assumptions. By removing these inconsistencies, this framework reduces unnecessary conceptual complexity without limiting physical generality.

The value of this framework lies in its logical consistency rather than in claims of completeness; accordingly, it does not conflict with **Gödel's incompleteness theorems**, which apply to sufficiently expressive formal systems that attempt to be both complete and consistent [35].

It must be clarified that non-existence is not synonymous with nothingness. Within this framework, existence is defined by the possession of an intrinsic property; consequently, non-existence refers to the logical complement which includes nothingness. The moment that you try to conceptualize nothingness, you are imagining something, and thus nothingness can't be conceived. For this reason, the ground state should not be associated with the term.

In *The Origin of Time In Conscious Agents* by Donald Hoffman (UC Irvine), consciousness is treated as a property. Furthermore, these conscious agents transition through a causal loop, similar to $S_Z(t)$, where perception, decision, and action form the states [36]. This aligns remarkably well with the FOE in regards to time, and establishes a rigorous framework to explore consciousness.

Free will necessitates the ability to change the value of α (eq. 23) without being causally required to. Newtons Laws would suggest this to be an impossibility, but nothing establishes that such laws hold at the existence level. In our everyday experience there is always some underlying physical law that dictates the state of Z, but in the absence of such a law, could Z freely choose? In this context, free will requires an absence of information, laws, or restrictions, thus opening to door to it potentially being more probable than determinism. From a purely evolutionary perspective, consciousness without free will would not help one survive since they couldn't alter their actions. However, this doesn't imply that consciousness isn't just an unavoidable outcome.

The Law of Interaction permits multiple universes within the same spatial region (e.g., $\mathcal{G}$). In this context, universes are distinguished by distinct sets of interacting properties and/or spatial separation, which aligns with the idea of a parallel universe [37] or the multiverse [38]. It therefore becomes necessary to establish a systematic method for identifying the full set of admissible properties that could identify a given universe; this likely requires a complete reliance on group theory in which every possible closed system may exist.

The current definition of science generally requires that a claim, theory, or equation be testable. However, as shown in Eqs. 12 and 18, the number of entities that are actually measurable may constitute only an infinitesimal fraction of what exists. At some point, our ability to measure new aspects of reality may reach a fundamental limit, raising the question of whether science can continue to progress under such constraints. In these circumstances, we are compelled to rely on the absolute consistency of logic as a tool to explore the entirety of $\mathcal{M}$ mathematically. For this reason, I propose that science be understood more broadly as encompassing any theory or claim that is both consistent with current observations and derivable from the FOE. To further justify this request, $c\,d\tau$ represents a concept of time that is distinct from the propagation of force carriers, whereas $c(t)\,dt$ is the concept of time that permits unification (eq. 32). Thus, while $c\,d\tau$ is a "working definition," it has resulted in over 100 years of struggle to unify physics. This illustrates the need for the FOE framework, where physics is subject to ontology, and ontology is derived from logic.

9 Conclusion

Equations establish relationships between variables, but our understanding of those equations depends on our initial assumptions about what the variables mean in reality. We can preserve the structure of equations, and thus the numerical predictions, while changing the ontological structure that they describe until both general relativity and quantum field theory treat space, time, and quantization uniformly. Thus, there is an ontological structure other than spacetime in which all known phenomena are explained through classical reasoning, and this ontological structure is derivable from a single axiomatic system in which mathematical theorems, ontology, and philosophy are also derivable.

10 Statements and Declarations

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The use of AI was limited to non-substantive tasks such as text formatting (e.g., paragraph structuring), technical error checking (e.g., verifying index placement), and general study assistance (e.g., clarifying existing physical concepts for self-study). No AI system contributed original scientific ideas, theoretical content, or conceptual development, nor is AI currently capable of doing so to the best of the author's knowledge.

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